

МОВНА СЕМАНТИКА В ЛІНГВОКУЛЬТУРНОМУ ТА КОГНІТИВНОМУ ВИМІРАХ

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AESTHETICS AND THE POWER OF STEAM

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У статті в лінгвокогнітивному аспекті розглянуто проблему інтеграції методів і прийомів вивчення мовних явищ з позиції філософії науки і філософії мистецтва. Автор робить спробу переосмислити зв'язок між наукою і естетикою, з'ясувати, у який спосіб природа естетики збігається або корелює з природою наукових теорій і методологій, або доповнює її. У центрі дослідницької уваги автора – не просто естетичний досвід людини в його сучасному, редукованому сенсі смаку, краси й задоволення мистецтвом, а роль сенситивної когніції, що є основою як наукових розробок людини, так і її мистецької діяльності. У пропонованій роботі представлено початкові результати теорії, на основі якої відбувається реконструкція поглядів на естетику як фундаментальну базу для людського досвіду, знань і креативної діяльності.

Ключові слова: філософія науки, філософія мистецтва, естетика, сенситивна когніція, мистецька діяльність.

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Introduction. In linguocognitive perspective the paper highlights the ways of integrating the methods of studying the linguistic phenomena from philosophy of science and the philosophy of arts points of view. The author tries to rethink the relation between aesthetics and the sciences, to explore the underlying nature of aesthetics arising from sensate cognition to discover whether or not it—and how, if it does—coincides, correlates, or complements the underlying nature of scientific theories and methodologies. **Purpose.** The paper focuses not on aesthetic experience only, in its modern, reductive sense of taste, beauty, and pleasure in the arts, but on the role of sensate cognition underlying all human cognitive processing including scientific investigation and most manifested in artistic activity. **Methods.** The paper presents the beginnings of a theory that reconstructs aesthetics as the foundational basis for all human experience, knowledge, and creative activity. It suggests a more productive approach to explore the underlying sensory-motor-emotive processes of sensate cognition in their relation to conceptual awareness. The paper gives a total reversal of what we have come to accept as undeniable divisions between the categories that make up the various “sciences” and those that constitute the various “humanistic” disciplines, as well as those that create divisions within those categories. **Results.** Cognitive activities include all the creations of human beings from artefacts to systems of thought, including mathematics and the sciences, to cultural and social institutions. Like the leaves of a tree that develop from the tree’s branches and trunk, these activities arise from our ability to conceptualize, to formulate conscious ideas and images. Beneath the surface of the cognitive tree lie the pre-conceptual, subliminal roots of sensory, motor, and emotive experiences that feed our conceptual awareness. Just as the living tree survives by drawing sustenance through its roots, so do all our cognitive activities depend on sensate cognition. And just as the roots of the tree are nourished by the quality of the material components of the earth in which they are embedded, so do the qualities of aesthetic imagination and judgment enable the flourishing of the physical and spiritual values that give rise to the harmonious balance of the self as part of the natural world. Perceptual imagining, as involved in the interpretation of scientific results, also plays an important role in the sciences. The perceptual content provided by the images constrains and shapes the imagination of the relevant objects. The objects are imagined on the basis of how they are perceptually experienced, and the resulting interpretations are formulated taking into account the perceptual imagination in question. **Conclusion.** The health of nature is therefore not metaphorical. Well-being imbues all of life, from

the air we breathe, the water we drink, the earth that sustains the life of plants, the sun that gives light and heat, from the smallest insect to the larger expanses of the universe. In maintaining the ideals and values of cultural well-being, we participate in maintaining the harmony and balance of the whole world. Greek thought recognized the truth of that reciprocity without assuming the need to prove it. What one draws from the lessons of *παιδεία* is the essential development of expertise in all human cognitive activity.

Keywords: philosophy of science, philosophy of art, aesthetics, sensate cognition, artistic activity

Introduction

The STEM educational initiative encourages students to study science, technology, engineering, and mathematics. While such encouragement is important, it is sadly remiss in ignoring the significance of aesthetics, the science of human cognitive activity, most – but not wholly – manifested in the practice and study of the arts. Hence the creation of the global STEAM project to put the arts into STEM (stemsteam.org). While practical activities in STEAM education are taking place in various places around the world, little attention is being paid to research on why and how the arts and the sciences may be integrated and practiced. To offset this apparent lacuna, Myrfield Institute for Cognition and the Arts [21] has set up a network to further research in integrating cognition, sciences, and the arts that will contribute to the STEAM project.

The argument for integrating the sciences and the arts has been made on many occasions [16]. There are three dimensions to the argument for integration: that it should happen, why it should happen, and how it can be achieved. Most current STEM/STEAM work assumes the “that” and moves directly to the “how”. This means that STEM/STEAM activities lack a sound theoretical basis. The British Education Research Association (BERA) [3] commission report on STEAM research makes the following comment in section 2 of the report:

STEAM inherits the tensions between S-T-E-M as four separate subjects, and their reconceptualisation as STEM through interdisciplinary connections and learning. There are some discussions on the relationships between different disciplines [3], but there remains little theorizing about the way in which the Arts and STEM can effectively work together to achieve the expected educational and economic outcomes [3, p. 32].

One of several issues raised in the report is that present applications and practice by participants in STEAM have not explored systematically the philosophical and empirical assumptions underlying the STEM initiative and the STEAM project. In particular, the report notes a definitional problem in the use of the “A” in STEAM:

Interwoven in the debates on the precise meaning of the “A” in STEAM, is a broader concern with the potentially diverging purposes of science education. These are generally recognised as pertaining to two main sets of concerns: education of STEM specialists, and education that includes the broader, ethical, and intellectual development of children, as persons and citizens [3, p. 34].

It is characteristic of such attempts as STEM – to improve educational possibilities and attract more students into the sciences – that policies and practices developed rely upon and tinker with established educational categories rather than questioning the legitimacy of their existence. Such reliance is evident in the BERA review in section 2.5 on research into the epistemology and ontological assumptions of STEM/STEAM that reveals “a lack of cumulative literature and ongoing critical debate in the STEAM field, nor is there detailed engagement with, or grounding in, the more technical philosophical literature” [3, p. 35–42]. It is from this perspective that MICA proposes its research contribution.

The principle that the sciences and the humanities are separate and independent disciplines stems from the eighteenth century Enlightenment. Giambattista Vico’s (1686[1744]) *Nuova Scienza* was written primarily as a response and challenge to Descartes’ introduction of a scientific methodology that Vico claimed worked for the natural sciences but not for the human sciences. The latter, therefore, Vico argued, needs a different methodology. Such a distinction reflects a sharp division between the sciences and the humanities that has dominated Western thought to the present day. That division is marked by the contrast between logical reasoning characteristic of scientific methodology, and sensory-motor-emotive (sensate for short) affects characteristic of the

humanistic disciplines. However, as cognitive scientists learn more about human cognitive processes that integrate the sensate and conceptual activities of human minding,¹ it becomes clear that such a division between the sciences and the humanities is overly simplistic. It lingers, however, in more subtle ways. Approaches to the natural sciences that assume humans are disconnected from the natural world still govern much scientifically oriented research. Adherence to the principles and methodologies of Cartesian science is vulnerable to reducing cognitive activity to what Raymond Tallis [27] calls extreme Darwinism and neuromania, both of which rely on material and physical mechanisms to the exclusion of self-awareness and human understanding and behavior.

In his study of how the mind emerged from constraints on matter, Terrence Deacon [9] argues for the need to rethink the structure of the natural sciences in order to accommodate a more complete understanding of the nature of human existence. In addition, if approaches in the humanistic sciences – psychology, sociology, anthropology, etc. – exclusively follow the rigorous methodology of the natural sciences, they automatically and necessarily exclude features such as purpose, intention, function, and value from their empirical investigations and analyses. Such an exclusion reflects their uneasy position, situated as they are between methodologies designed to explain natural, physical processes and the existence of living, sentient, thinking, and feeling organisms. The question for cognitive research, therefore, is: What is needed in order to overcome the inevitable dualism that arises from separating both material objectivity from spiritual subjectivity and human life from other life organisms?

To answer that question, we need to return to pre-Cartesian assumptions. We need to undo all the presuppositions that have cluttered Western thought over the centuries in order to reconceive the relation between our understanding of the self and the worlds of our experience. One way to do so would be to compare the traditions of non-Western societies that are based on quite different presuppositions. But first groundwork needs to be laid down that exposes outdated assumptions of Western thought that still underpin much current discussion. There are two approaches that contribute to doing so. Historically, evidence exists in earlier Western cultures for a more unified understanding of the relation between science and art. In Walter Isaacson's [14] biography of Leonardo da Vinci, he shows that fifteenth-century Florence was grounded in aesthetics across all activities, scientific, technological, mathematics, engineering, and the arts, and that such activity is most manifest in da Vinci's life: "just as Leonardo's anatomy informed his art, so was the reverse true: his artistic, sculpting, drawing, and engineering skills crossed disciplines and aided his anatomical studies" [14, p. 403]. Current cognitive studies, both in the sciences and the arts, as we shall see in subsequent sections, is already challenging our modern, technological, view of the world and our relation to it. The potential power of the STEAM project can operate only when harmonious integration is achieved in recognizing the embodied experience of knowledge in all its forms, both in the theory and methodologies of the natural sciences and in the experience and practice of the arts and humanities. That integration occurs, I argue, in understanding sensate cognition as the wellsprings of aesthetics that underlie and help to formulate pertinent and productive cognitive activity.

What we need for MICA's STEAM research network in addition to researchers in aesthetics and the arts are scientists and philosophers of science who can speak from their own intimate knowledge about the fundamental characteristics of scientific research. Over the past few decades, an increasing number of publications has been devoted to the relation between aesthetics and the sciences, from researchers in both the philosophy of science and the philosophy of art.² Much of

1. Reification (the creation of objects) through nominalization (turning verbal activity into noun concept), necessary for cognitive economy, leads to assumptions that obscure and mislead, so that we think of "mind" as something that exists and that therefore can be "contained" within a spatial dimension. But mind does not exist as an object. It is an activity. I therefore adopt the term *minding* to avoid misconception.

2. A comprehensive listing of both approaches may be found in cited references in the articles published in Currie et al. (2014) and Bueno et al. (2018).

this research raises the question of how implicit presuppositions of Western thought still underlie attempts to rethink the relation between science and aesthetics. It is not my intention here to explore the various approaches and arguments addressed in such research. Rather, I wish to explore the underlying nature of aesthetics arising from sensate cognition to discover whether or not it – and how, if it does – coincides, correlates, or complements the underlying nature of scientific theories and methodologies. My focus, therefore, is not on aesthetic experience per se, in its modern, reductive sense of taste, beauty, and pleasure in the arts, but on the role of sensate cognition underlying all human cognitive processing including scientific investigation and most manifested in artistic activity [10, p.717–752]. In this presentation, therefore, I present the beginnings of a theory that reconstructs aesthetics as the foundational basis for all human experience, knowledge, and creative activity. Needless to say, my hypotheses are subject to challenge and testing.

Aesthetics of Sensate Cognition

Aesthetics as the wellsprings of sensate cognition is an activity of minding. This self-evident fact should not surprise. Sensory perception, imagination, and judgment involve the relation of our inner responses to our experiences of the external world. That relation is primarily intuitive and emotional, not analytic and conceptual. An adherence to modern scientific methodology that values abstraction, generalization, experiment, and prediction, in spite of the turn away from the mind-body split that characterizes such methodology, has resulted in an indifference, if not ignorance, toward the intuitive workings of human minding.

The term *cognition* has historically been understood as referring to the conceptual reasoning processes of human mental activity, most manifested in the rational, logical methodology of the natural sciences, as distinct from the sensory, emotional, and irrational. This division is understandable, since logical reasoning seems to be what distinguishes the human species as unique. It is what has led to the split between the sciences (rational, logical) and the arts (sensory, emotive). However, recent work in the cognitive sciences is providing a much more complex picture of human cognition that includes the imagination and understanding. One can picture cognition in the form of a living tree (Fig. 1):

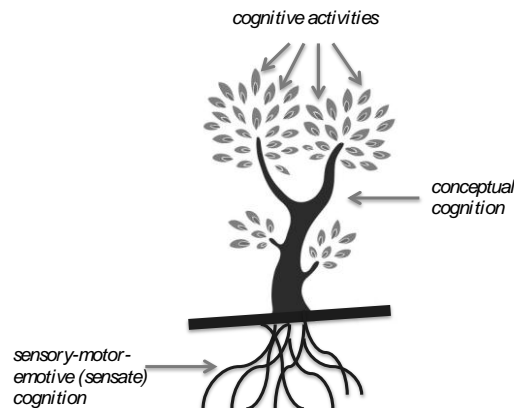


Figure 1. Picture cognition in a form of a living tree

Cognitive activities include all the creations of human beings from artefacts, artistic or otherwise, to systems of thought, including mathematics and the sciences, to cultural and social institutions. Like the leaves of a tree that develop from the tree's branches and trunk, these activities arise from our ability to conceptualize, to formulate conscious ideas and images. Beneath the surface of the cognitive tree lie the pre-conceptual, subliminal roots of sensory, motor, and emotive experiences that feed our conceptual awareness. Just as the living tree survives by

drawing sustenance through its roots, so do all our cognitive activities depend on sensate cognition. And just as the roots of the tree are nourished by the quality of the material components of the earth in which they are embedded, so do the qualities of aesthetic imagination and judgment enable the flourishing of the physical and spiritual values that give rise to the harmonious balance of the self as part of the natural world.

Most of the work that I have read so far in exploring aesthetics from a cognitive science perspective relies upon the roles of interpretation and representation that deal with taste, beauty, and pleasure rather than on those of imagination and understanding that deal with purpose, intention, function, and value [12, p. 308–322]. As a result, ongoing debates over aesthetics as a philosophy of perception are to my mind stymied by their focus and doomed as unresolvable. Instead, I suggest that a more productive approach is to explore the underlying sensory-motor-emotive processes of sensate cognition in their relation to conceptual awareness that are characteristic of the aesthetic faculty. In doing so, I suggest a total reversal of what we have come to accept as undeniable divisions between the categories that make up the various “sciences” and those that constitute the various “humanistic” disciplines, “as well as those that create divisions within those categories. To do so, I need to revisit the whole question of how human cognitive processes enable us to acquire experience and knowledge and to engage in creative activity. I begin by exploring the roots of the STEAM disciplines.

By the turn of the twentieth century, philology, the etymological study of words, was still known as the Queen of the Sciences. Despite the modern meanings attached to STEM labels, their proto-Indo-European roots reveal that their origins lie in embodied human experience.³ The word **Science** comes from the Latin, *scientia*, knowledge, from *scire*, to know, which itself derives from the proto Indo-European *skei*, the extended root of *sek-*, to cut, meaning to physically separate one thing from another, hence “discern.” The Greek word for science, ἐπιστήμη, with its roots in *stā-*, to stand in a place, gives us epistemology, the understanding of the nature and origin of knowledge from our own embodied grounded perspective. In early Greek thought, ἐπιστήμη, with its verb form meaning knowing “how” as well as “that”, was closely related to τεχνη, the art and craft of practical knowledge, giving us **Technology**. Its proto-Indo-European root is *teks-*, weaving or fabricating, associated with making wicker or wattle fabric for (mud-covered) house walls; hence the Greek τεκτον, carpenter, builder. The word **Engineering** comes from Latin *in-gen*, the root of *gignere*, to beget, itself coming from the Greek γίγνεσθαι, to be born. Its proto-Indo-European root *gene-*, to bring into being, is directly related to the Greek γένεσις; hence *ingenium*, ingenuity, the art of contriving, designing, inventing. The Greek word μάθημα, knowledge, study, learning, from proto-Indo-European *mendh-*, to learn, gives us **Mathematics**, understood as the foundation of philosophy and all the sciences. Finally, the word **Arts**, in the history of its etymology, is related to all three STEM words. It comes from the Latin *ars*, *artem*, skill, and the Greek ἄρμος, a joining, joint, from the proto-Indo-European *ar-*, *are-*, to fit together, as the shoulder and arm are joined; hence the word harmony. The *American Heritage Dictionary* also gives two variant forms for the proto-Indo-European *ar-*, *are-*: 1) *ōr-dh-*, the Latin *ōrdō*, order (originally a row of threads in a loom) and *ōrnāre*, to adorn; and 2) *rē-*, the Latin *rēri*, to consider, confirm, ratio, giving us “ratio” and “reason”.

The Greek term for sensory perception is αἴσθησις, related to discernment and understanding that comes from conceptualizing the sensory-motor-emotive level of our cognitive processing. Gottlieb Baumgarten [2] coined the term *aesthetics* as the science of sensory perception. Although its modern meaning has reduced its application to taste, beauty, and pleasure in the arts, I argue that taste, beauty, and pleasure are products arising from the aesthetic faculty, not the faculty itself. The aesthetic faculty involves the purpose, intention, function, and value ascribed to our imaginative understanding. It reflects the ability to discern, to discriminate, thus to distinguish

3. In 1969, Houghton Mifflin published *The American Heritage Dictionary of the English Language*, edited by William Morris. Compiled by many experts and specialists, it was the first dictionary to provide a comprehensive index of the proto-Indo-European roots of the Indo-European family of languages that includes European and Asian language groups. Discussion of these roots in this section are drawn from this dictionary.

qualitatively the good from the bad, the right from the wrong, the ugly from the beautiful, the true from the false. In that sense, then, it underlies the applications of embodied experience reflected in the etymologies of STEAM. The aesthetic faculty thus powers all STEAM pedagogical activities. In what follows, I begin the process of exploring the way aesthetics underlies expertise in the arts and the sciences in order to provide the groundwork for suggestions as to how aesthetics might provide the basis for integrating STEAM pedagogy.

Aesthetics of Art

Recent work in aesthetics and the cognitive sciences has brought into question the relation between aesthetics and the arts. Bence Nanay [22], in focusing on aesthetics as part of the philosophy of perception, notes that “we should detach aesthetics from art, but to do so carefully. Aesthetic experience is neither necessary nor sufficient for the experience of works of art. We can experience works of art in a non-aesthetic manner and we can experience objects other than works of art in an aesthetic manner” [22, p. 102–103].

Because, in our egoism, we see ourselves as different from all other natural organisms, we have in our ignorance denied our connections to nature. For example, John Ruskin [25] coined the term *pathetic fallacy* to characterize an “emotional falseness” that occurs when human emotions are attributed to the nonhuman. A close reading of his “pathetic fallacy”, however, reveals that Ruskin distinguished between the fallacy of “false appearances” that are “entirely unconnected with any real power or character in the object, and only imputed to it by us” and true appearances that legitimately identified the way external things could by their own characteristics invoke in us like feelings: “Thus, when Dante describes the spirits falling from the bank of Acheron” as dead leaves flutter from a bough, “he gives the most perfect image possible of their utter lightness, feebleness, passiveness, and scattering agony of despair, without, however, for an instant losing his own clear perception that *these* are souls, and *those* are leaves; he does not confuse one with the other” [25, p. 156].

In Ruskin’s example, Dante’s analogy between dying souls and falling leaves is true to both domains because there is no confusion of pure identity between the two: the physical attributes of the falling leaves – light, frail, passive, and scattering – are metaphorically transformed into descriptions of the souls’ emotional succumbing to despair. Ruskin, however, creates a fallacy of his own when he fails to differentiate between attribution and identification. That is, he compares Dante’s lines with Coleridge’s “The one red leaf, the last of its clan, / That dances as often as dance it can”, and claims that Coleridge has a morbid, that is to say, a so far false, idea about the leaf : he fancies a life in it, and will, which there are not; confuses its powerlessness with choice, its fading death with merriment, and the wind that shakes it with music. Here, however, there is some beauty, even in the morbid passage [25, p. 156].

Here, Ruskin is suggesting that it is false to anthropomorphize, to project uniquely human attributes onto things in nature. However, he also notes “that the spirit of truth must guide us in some sort, even in our enjoyment of fallacy. Coleridge’s fallacy has no discord in it”. I suggest that “the spirit of truth” he finds in Coleridge’s lines rests rather in an understanding of the sensory experience of seeing the last red leaf moving rhythmically as the wind takes it in terms of a dancer moving rhythmically to the sound of music. The leaf *is* dancing, if we recognize that such activity can describe non-human processes as well as human ones. If a leaf can be dead, it must also have been alive. That is, the idea that we are always anthropomorphizing when we extend language across natural species results from the assumption that we as humans are different in kind, that we have nothing in common with the rest of the natural world.

My point that language usage may extend beyond human cognitive activity is further supported by cognitive science research into animal and plant behavior. In the middle of the twentieth century, much debate occurred between linguists and psychologists as to whether or not chimpanzees like Washoe and Sarah had broken the human language barrier. When Holyoak and Thagard [13] revisited the psychologists’ data, they focused not on language per se, but on the cognitive abilities evidenced by the chimpanzees’ performances. What emerged from their research is that chimpanzees have certain cognitive capacities that they share with humans.

Similarly, the work of cognitive scientists and philosophers like David Abram [1], Carl Safina [26], and David George Haskell [11] restore humans to the biological and cognitive networks that make us part of nature.

Art has the capacity to conjure up the feelings of experiencing the concrete, precategorical world as it is before the mind conceptualizes it. Joseph Conrad [6], in his preface to *The Nigger of the Narcissus*, expresses succinctly this notion of poetic art: “A work that aspires, however humbly, to the condition of art should carry its justification in every line. And art itself may be defined as a single-minded attempt to render the highest kind of *justice* to the visible universe, by bringing to light the *truth*, manifold and one, underlying its every aspect. It is an attempt to find in its forms, in its colors, in its light, in its shadows, in the aspects of matter and in the facts of life, what of each is fundamental, what is enduring and essential – their one illuminating and convincing quality – *the very truth of their existence*. My task which I am trying to achieve is, by the power of the written word, to make you hear, to make you feel – it is, before all, to make you see. That – and no more, and it is everything” [6, p. 8].

Conrad’s focus on justification and truth characterizes art, not simply in terms of taste, beauty, and pleasure, but as a way of accessing truth. In this sense, the arts complement the scientific search for truth. Both involve the strive for perfection that is characterized by beauty. Just as carpenters judge the “true line” of measurement in their intention to produce perfection in their work, so do artists and scientists, technologists, engineers, and mathematicians search for the perfection of truth. That, I believe, is what Emily Dickinson meant by saying Beauty and Truth “are One” in her poem *I died for beauty*, and Keats meant by the final lines of his “Ode on a Grecian Urn”: “Beauty is truth, truth beauty, – that is all / Ye know on earth, and all ye need to know”. The aesthetic faculty as a search for the beauty of truth is as much a factor in the sciences as it is in the arts.

Aesthetics of Science

It is a commonplace assumption in science that normal folk understanding of the worlds of our experience do not adequately explain the reality of the universe. Early humans perceived the world as flat; the sun, moon, and stars existed within perceptual distance in space. It has taken centuries of scientific exploration into the unseen to show us that we live in a time-space universe, with the planets and stars visible across time as well as space. Modern scientific explorations continue to show how conceptual awareness of human experience is not the whole story. Sounds below the level of human hearing affect our bodily organs below the level of our conscious awareness [31]. Bodily motions affect what we see [23]. Visceral activities in our bodies subliminally affect our moods and emotions [8].

Scientists develop hypotheses through the same perceptual imaginative strategies that constitute all cognitive behavior, such as creating models, idealizations, and depictions of the realities they are exploring that they then test to discover to what extent they reflect observed reality. In doing so, they are metaphorically mapping between observed data and abstract explanation [29]. The contributors to *Thinking About Science, Reflecting on Art: Bringing Aesthetics and the Philosophy of Science Together* provide many examples of scientists imagining thought experiments, fictionalized ideas that are impossible to realize but lead to hypotheses that revise prior notions about the world and the nature of the universe [4]. A classic example is Einstein’s discovery of the relativity of time from visualizing what would happen if one could travel at the speed of light. In quoting Einstein’s discovery that “the knowledge that the events which are simultaneous for one observer are not necessarily simultaneous for another”, Arthur Koestler [17] notes that Einstein described the “physical entities which seem to serve as elements in thoughts” in terms of “signs and more or less clear images of visual, and some of muscular type” [17, p. 184].

In their book on mathematics, Lakoff and Nuñez (2000) show how the nature of mathematic ideas are rooted firmly in human cognitive processing. As a result, they apply the following principles to mathematics:

1. *The embodiment of mind.* The detailed nature of our bodies, our brains, and our everyday functioning in the world structures human concepts and human reason. This includes mathematical concepts and mathematical reason.

2. *The cognitive unconscious.* Most thought is unconscious – not repressed in the Freudian sense but simply inaccessible to direct conscious introspection. We cannot look directly at our conceptual systems and at our low-level thought processes. This includes most mathematical thought.

3. *Metaphorical thought.* For the most part, human beings conceptualize abstract concepts in concrete terms, using ideas and modes of reasoning grounded in the sensory-motor system. The mechanism by which the abstract is comprehended in terms of the concrete is called *conceptual metaphor*. Mathematical thought also makes use of conceptual metaphor, as when we conceptualize numbers as points on a line [17, p. 5].

As Otávio Bueno [4] notes, “Perceptual imagining, as involved in the interpretation of scientific results, also plays an important role in the sciences” [4, p. 96]. He gives the example of George Palade [24, p. 59–79] who did not know what he was seeing when he saw dots in the membranes of cells in his electron microscope images that turned out to be ribosomes: “In order to imagine certain features of the ribosomes, Palade was being guided by the perceptual information provided by the electron microscope. In this process, he was invoking a form of perceptual imagination that is similar to the one involved in the experience of [cinematic] films. In both cases, the perceptual content provided by the images constrains and shapes the imagination of the relevant objects. The objects are imagined on the basis of how they are perceptually experienced, and the resulting interpretations are formulated taking into account the perceptual imagination in question” [24, p. 96].

Aesthetics of Expertise

The inculcation of the perceptive faculties is a crucial element in the development of expertise in any form of human activity, from the practical skills of technicians, the creativity of artists, all the way to the most abstract reasoning of the physical sciences. Science evolved to answer questions about the world; art to explore the ways we experience the world. Both depend on the creation of human artefacts. Their difference lies in the purposes for which such artefacts are made. Scientific instruments are designed to probe and test hypotheses about the natural world; cultural instruments create the ability to simulate human relationships and responses to the natural world. Neither the sciences nor the arts can proceed without the development of instruments. Think of Galileo’s telescopes, the electron microscope, the CERN reactor, computers, and robots. In the plastic arts, the instruments are material: wood, clay, concrete, steel in sculpture and architecture; oils, watercolors, canvas, parchment in the visual arts; brass and other metals, wood, ivory, skin in music. In other arts, the instruments are more closely related to the human body: muscular movement in dance, vocal chords in singing and oral poetry. Literature lies at the interface between artefact and body: early scribal implements, ink, pencil, paper, and later, computers, cameras, film, are at the service of language, which emerged in the development of human cognition [19]. For such activities to be successful, expertise is required. And that expertise, I argue is grounded in aesthetic perception.

Evaluative judgment in the arts is based on how well artists manage through their own makings to create an iconic semblance of reality in all its particularities as it exists in the lived experience of minding (Freeman, in process). Evaluative judgment in the sciences is based on how well their models accord with reality and how well the practical applications of technology and engineering meet the demands of human life. The reality of the world scientists and artists explore is the same; the approach they take results in a different kind of knowledge, the difference between “knowing” and “understanding (wisdom)”, *conoscere* and *sapere*, *connaître* and *savoir* [5, p. 193]. What underlies both approaches is the aesthetic faculty, the ability to imagine and understand one’s purpose, intention, function, and value in doing something well, whatever that “something” may be. Expertise in any given area is governed by an aesthetic perspective. That is what lies at the heart of *paideia* and at the core of pedagogy.

The Greek Notion of Παιδεία

As noted earlier, Baumgarten coined the term *aesthetics* from αἴσθησις, the Greek term for sensate cognition. Baumgarten's thesis reflects the post-Cartesian assumptions of scientific methodology that resulted in the separation of sensate experience from rational thought [10]. For early Greek culture in the centuries before the Christian era, that separation did not exist. Werner Jaeger's (1933–1947) mammoth three-volume study of *Paideia: The Ideals of Greek Culture* traces the development of Greek cultural education from a belief in the notion of symmetry between world and self, resulting in an integration of both physical and psychological processes in human cognition. Thinking, then, in the words of one classical Greek commentator, is "the soul's walk abroad", understood by Jaeger as the extension of physical exercise from the body to the soul's interaction with the world [15, p. 298]. The relation of human life to the natural world, according to early Greek thought, is not one of analogy but of reciprocity. Richard Tarnas [28] defines *Paideia* as: "the classical Greek system of education and training, which came to include gymnastics, grammar, rhetoric, poetry, music, mathematics, geography, natural history, astronomy and the physical sciences, history of society and ethics, and philosophy – the complete pedagogical course of study necessary to produce a well-rounded, fully educated citizen" [28, p. 29–30].

The ideals of παιδεία are both physical and spiritual, creating a state of harmonious balance. Physical and spiritual virtues both imbued the natural order of nature to create an equality and harmony that caused, in Jaeger's words, the notion of 'health' to mean something greater – it grows into a universal standard of value applying to the whole world and the whole of life. For its foundations, equality and harmony, are the forces which (according to the ideas underlying this doctrine) create that which is good and right, while pleonexia, aggrandizement, disturbs it. The reason why medicine rose to such a representative position in Greek culture was that it revealed, clearly and impressively, in the sphere most accessible by immediate experience, the inalienable significance of this fundamental Greek ideal. In this higher sense, we may say that the Greek ideal of culture was the ideal of Health [15, p. 45].

The health of nature is therefore not metaphorical. Well-being imbues all of life, from the air we breathe, the water we drink, the earth that sustains the life of plants, the sun that gives light and heat, from the smallest insect to the larger expanses of the universe. In maintaining the ideals and values of cultural well-being, we participate in maintaining the harmony and balance of the whole world. Greek thought recognized the truth of that reciprocity without assuming the need to prove it. What one draws from the lessons of παιδεία is the essential development of expertise in all human cognitive activity.

Conclusion

What I hope to have shown in this paper is why a pedagogical initiative that focuses exclusively on science, technology, engineering, and mathematics without including the arts will not produce the kind of results needed to inculcate the kind of cognitive well-being of future generations reflected in the Greek notion of παιδεία. Nor will teaching the disciplines as separate subjects. Although it is beyond the scope of this paper to describe how STEAM might be reconceptualized as integrative study, I end with a tentative outline of how a focus on aesthetics might motivate pedagogical education.

One important factor in providing a comprehensive education for our students is to ensure that it is developmental in nature. As practical applications of the STEAM project show, education at the elementary levels is already evidencing successful ways that children may be introduced to the aesthetic concepts of ingenuity, problem-solving, design, and making, that integrate principles shared among STEAM subjects (see stemtosteam.org for details). Isaacson lists the components of Leonardo's ingenuity that reflect the fundamental principles of aesthetics: observation, curiosity, experiment, questioning, pattern discovery, analogy [14, p. 176]. Unfortunately, at higher levels the demands of specialization deflect the focus on such aesthetic fundamentals in mastering the principles of the subjects studied. By the time students reach college, if they do, the vast array of electives that lead students to opt for the easy grade, or choosing courses to simply train for work that will bring financial rewards, further erodes the developmental principles of παιδεία.

I do not hold much hope for the thorough overhaul of educational curriculum that is needed. However, I end with one ray of hope. Education in any subject involves the development of expertise. As I hope to have shown, the salient elements that constitute the aesthetic faculty are the same for the arts, the humanities, and the sciences, exemplified in the etymological roots of all the STEAM subjects. Inculcating the ability to discriminate, to discern what is true, valuable, good, and beautiful in all chosen fields of endeavor can happen, if only we guide our students from the aesthetic perspective.

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